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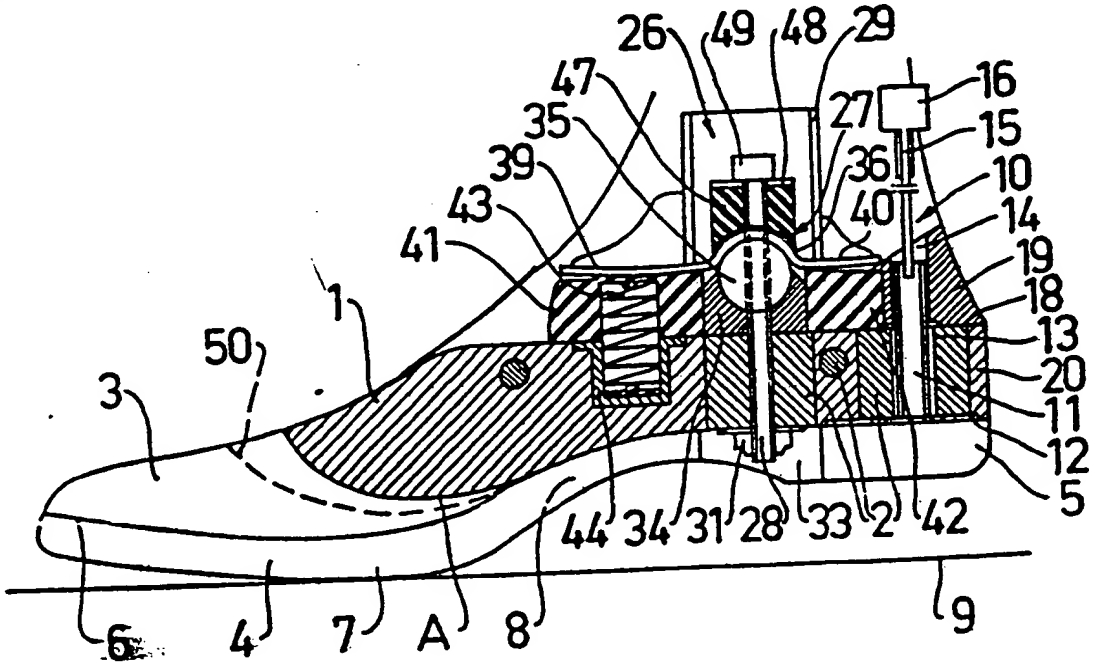
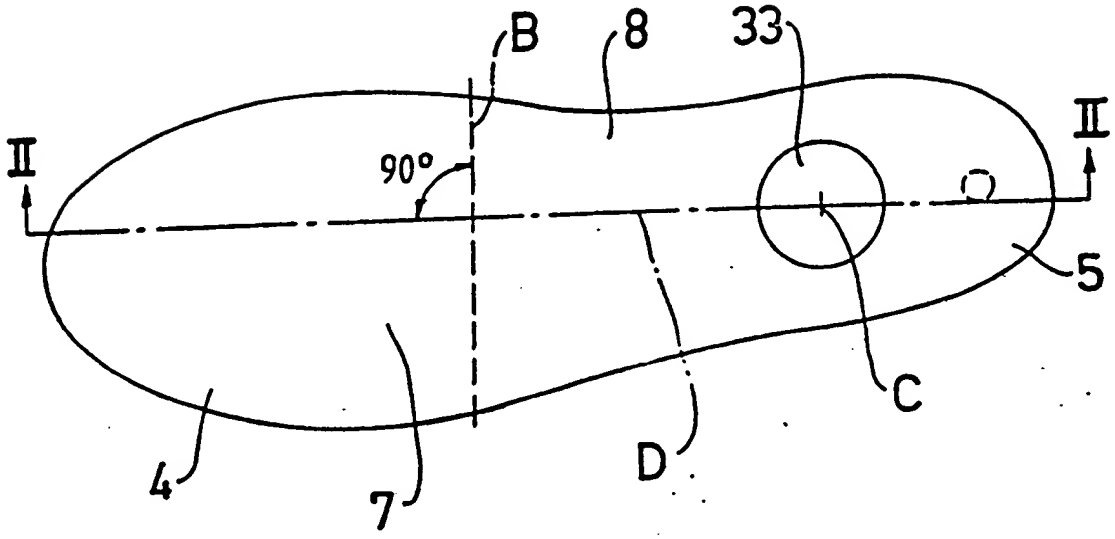


(57) Abstract

Device in a prosthesis where the prosthesis foot and the lower leg are mutually connected through a joint permitting relative motion between the prosthesis foot and the lower leg with increasing resistance from cushioning means arranged at least on both sides of the joint. In order to improve the walking freedom of such foot prostheses the joint (27) is braked by means of an adjustable force transmitted at least via the weight of the prosthesis carrier also before an engaging contact with any one of said cushioning means (41, 42) located on both sides of the joint (27).

FIG.1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90°
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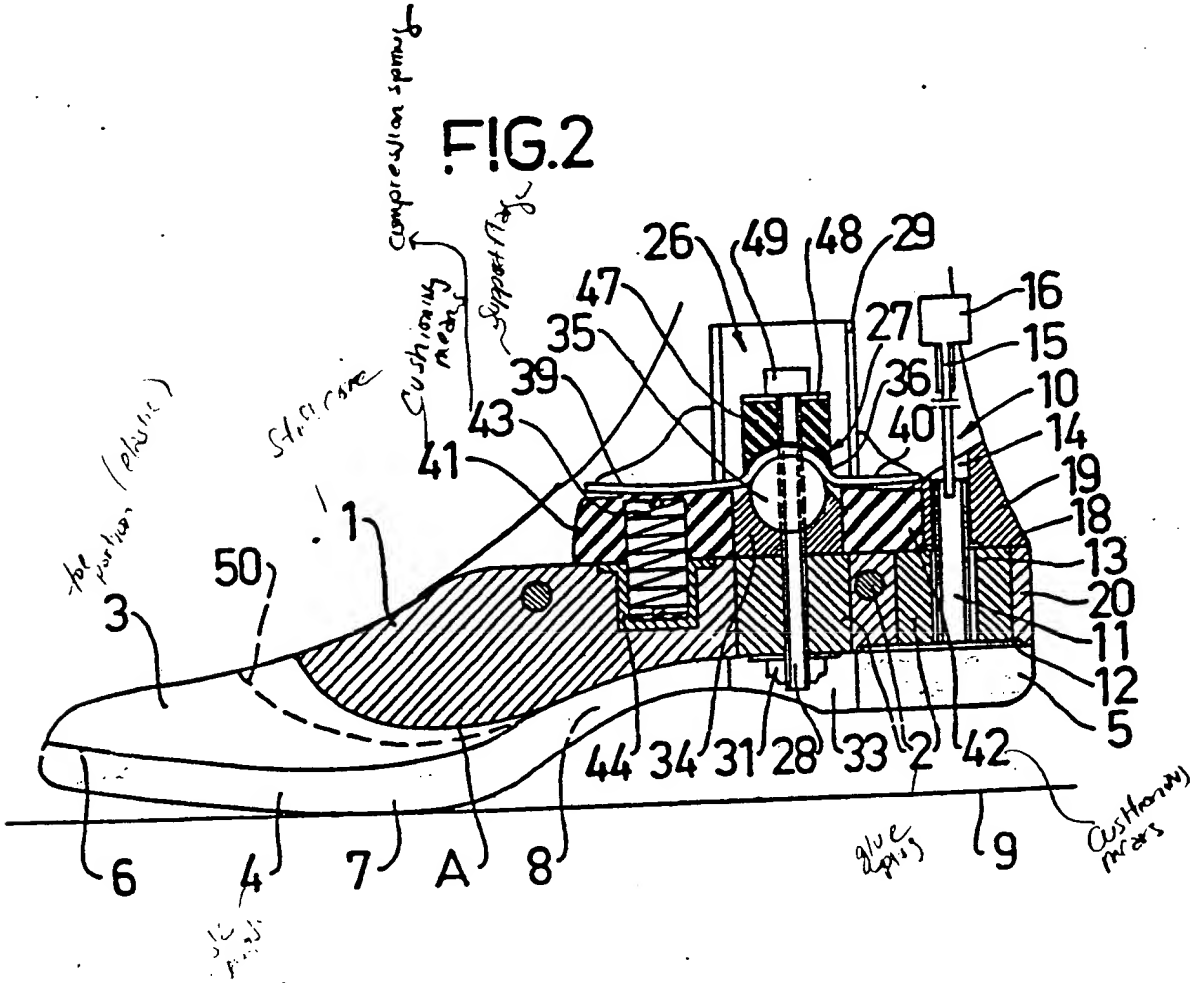
FIG.2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44
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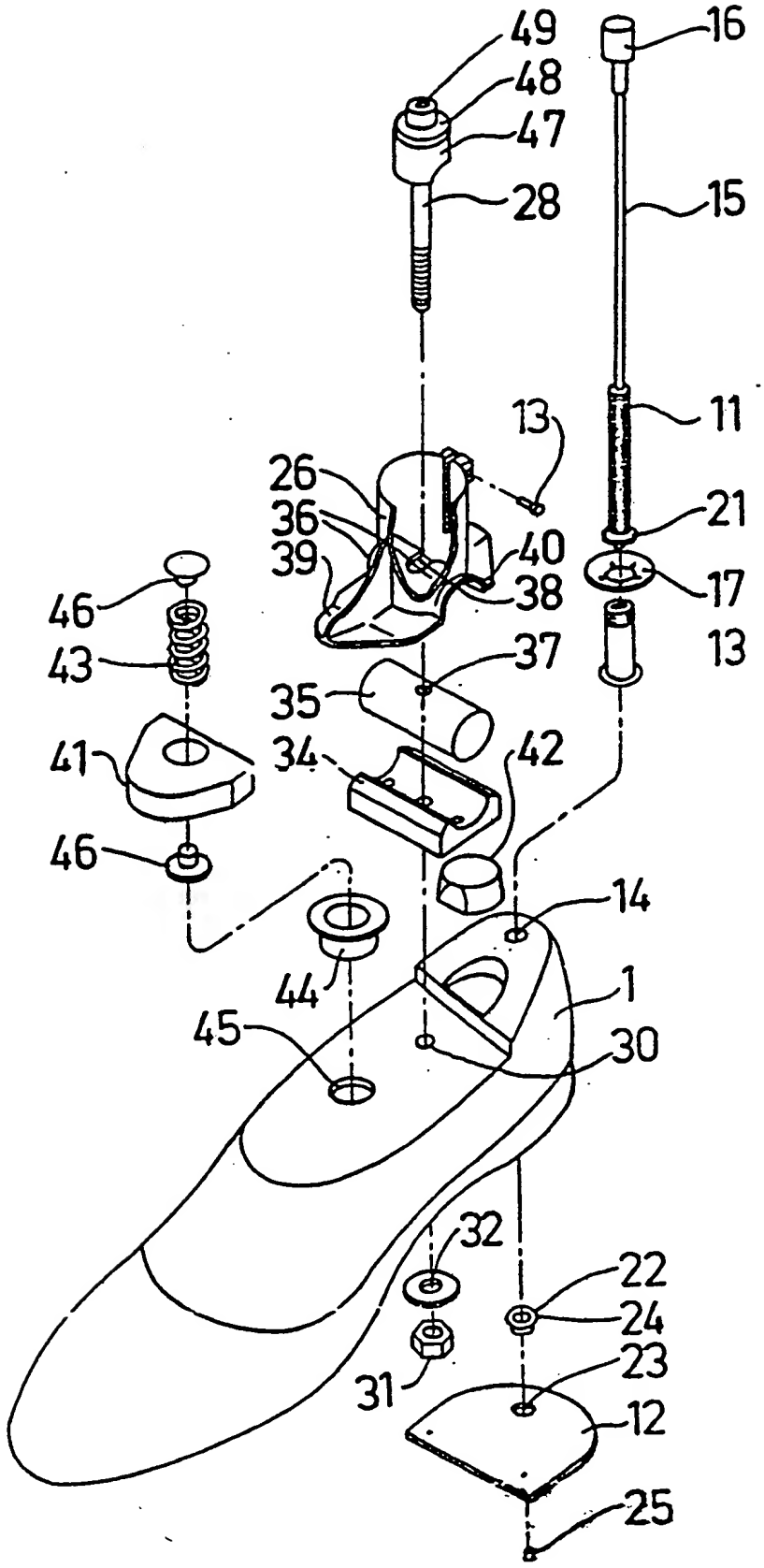
FIG.3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I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)

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II. FIELDS SEARCHED

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SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category 10	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No. 13
Y	GB, A, 2 092 451 (CHAS A. BLATCHFORD AND SONS LTD) 18 August 1982 & GB, 2070439	1-6
A	FR, A5, 711 480 (M. JEAN ET AL) 10 September 1931	1-6
Y	US, A, 1 572 319 (A.D. SCULLY) 9 February 1926	1-6
Y	US, A, 2 066 599 (S.A. WILLETT) 5 January 1937	1-6
A	US, A, 2 183 076 (W.F. KAISER) 12 December 1939	1-6
A	US, A, 2 439 195 (H.M. WITMYER ET AL) 6 April 1948	1-6
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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1988-05-19	1988 -05- 25
International Searching Authority: Swedish Patent Office	Signature of Authorized Officer: Leif Karnsäter

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81

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Prosthesis with a Joint between Foot and Lower Leg

This invention relates to a device in a prosthesis where the foot and lower leg are mutually connected through a joint permitting relative movements between the prosthesis foot and the lower leg with resistance from elastic cushioning means arranged at least on both sides of the joint.

Many attempts have been made to provide leg or foot prostheses with a prosthesis foot serving to a maximum extent as the biological foot in respect of motion possibilities and patterns and the feeling of the necessary steadiness and being felt as such a one during walking not only on plane ground but also in descent and ascent. However, these attempts have not given satisfactory results but said problems still remain to a certain extent which, thus, have appeared to be extremely difficult to solve definitively. The comprehensive patent literature available in this field also bears witness to this and shows a lot of suggestions as to different solutions.

Usually these known solutions are based on the use of an articulate shaft arranged in the transverse direction of the foot and a spherical ball bearing arranged thereon and providing flexibility in substantially all directions. However, by this type of joint construction the required steadiness is not even achieved by using cushioning means of rubber or a similar material arranged in front of as well as behind the articulate shaft, and therefore this type of prosthesis foot is very difficult to walk with even on a plane surface and almost impossible to walk with in descent and ascent and up- and downstairs.

In order to achieve movability in all directions for a foot prosthesis in relation to the prosthesis lower leg it is also previously known to form the foot

prosthesis as a hollow, coherent core that is to form in itself a joint system and is rigidly connected to a leg prosthesis adapter without elastic or articulate members, the desired articulate and supporting functions desired during walking substantially being achieved by a direct contact between the guiding leg prosthesis adapter and the hollow core of the foot. However, this means great stresses on the material in the core of the foot prosthesis, and in order to reach the desired articulate function the walls of the core must be relatively thin, and therefore a contrasting relationship between the required strength in respect of static stresses and flexibility is built into this prosthesis construction which cannot be combined in materials known so far without the risk of a breakdown in some form. As is well-known, this known construction has therefore not been used in practice.

Further, most of the known foot prostheses have the disadvantage that they often cause wear of sound knee- und hip-joints and have an inherent unbalance making it more difficult for the user to walk even on plane ground than what should actually be the case and results in a relatively rapid deformation of the prosthesis foot that must therefore be replaced rather often like used shoes which due to this relatively rapid deformation of the prosthesis foot are also worn rapidly and unevenly.

It is therefore the object of this invention to provide a foot prosthesis or a leg prosthesis containing a prosthesis foot not having the above-mentioned disadvantages but being so constituted that it serves in all essential respects as a biological foot as regards walking freedom on plane ground, in descent and ascent and up- and downstairs and which, moreover, does not cause wear of sound knee- and hip-joints.

This is achieved in that the prosthesis of the invention has been given the characteristic features defined in the claims.

The invention is described in the following in greater detail with reference to the enclosed drawings, wherein Fig. 1 shows the prosthesis foot as seen from below, Fig. 2 shows a section of the prosthesis foot taken along the line II-II in Fig. 1, and Fig. 3 is an explosive view of the foot prosthesis.

A stiff, homogeneous core 1, preferably of wood, optionally with a glue line and glued plugs 2 of wood or another equivalent material to avoid crack formation and the like, is included in the foot prosthesis of the invention. A body of an elastic material forming the toe portion 3 and sole 4 with heel 5 of the foot is attached to the underside of the core, the borderline between toe portion 3 and sole 4 being marked with a line 6. The region between the toe portion 3 and the core 1 is so disposed that the toe portion 3 comprises a joint corresponding to one toe joint and forming the flexibility of the elastic material used in the toe portion, for example rubber, a rubber mixture or a corresponding plastic material. The material used in the toe portion 3 should have a greater hardness than the material in the sole 4 and the heel 5, for example 40-80 Shore, conveniently 60 Shore and 30-70 Shore, respectively, preferably 40-50 Shore.

The body including the toe portion 3 and the sole 4 with the heel 5 is rigidly connected to the core 1 at least up to the point A which is shown in Fig. 2 as being located straight above the line B of the pad section 7 around which the foot bends during walking and along which the sole is vaulted in its arch portion 8 in order that the foot prosthesis should suit all types of shoes. Moreover, the sole 4 has its underside so

formed that said line B as well as the underside of the heel 5 should be parallel to a plane surface 9 with the prosthesis foot placed on said surface. In the embodiment of the invention shown on the drawings the sole 4 with its heel 5 is loosely arranged from the point A relative to the core 1 and is movably connected with the heel 5 to the rear portion of the core through an adjusting device 10, by means of which the heel 5 is vertically adjustable relative to the pad portion 7 of the sole. In this way it is possible for the carrier of the prosthesis to use shoes having a different heel height and to walk with the prosthesis without shoes in a normal way.

Said adjusting device 10 can comprise in a way known per se an adjusting screw 11 which is rotatably but not axially movably attached to a pressure absorbing and distributing plate 12 anchored in or to the heel 5 and extending through an internally threaded sleeve 13 rigidly arranged in the core 1. Above this the adjusting screw 11 extends with a free fit up through a hole 14 in the core 1 and is rigidly connected at its upper end to a torsion-proof thread 15, for example a wire, which is provided with a turning knob 16 by means of which the prosthesis carrier can turn the adjusting screw manually without bending and displace in this way the heel 5, which is pivotable thanks to the elastic material of the sole relative to its toe portion 3 and pad portion 4 rigidly connected to the core 1, away from and towards the core 1 for adjusting it to the intended vertical position in dependence on the heel height of the used shoe.

In Fig. 3 the adjusting device is also shown to comprise a locking washer 17 which, when threaded onto the sleeve 13 applied in the core 1, is in a dividing plane 18 between two parts 19, 20 of the rear portion

of the core joined to each other, the upper part 19 being glued or threaded onto the lower part 20. Moreover, it is shown in Fig. 3 that the adjusting screw 11 is provided at its lower end with a slide bearing flange 21 for slide bearing contact with a corresponding slide bearing flange 22 of a sleeve 24 arranged in a hole 23 in the plate 12 and is locked against axial displacement by a screw 25 bearing against the side of the plate facing the heel 5 and threaded into the adjusting screw.

Furthermore, the present foot prosthesis is provided with an adapter 26 for rigid connection of a prosthesis lower leg, said adapter being articulatedly attached to the core 1 of the prosthesis foot through a joint means 27 having a stiff, i.e. non-flexible joint connection stud 28 extending through the articulate device and the core 1. This stud should form a right angle with the support 9 when the inventive prosthesis foot, correctly adjusted for walking, is resting with its pad portion 7 and its heel 5 against the underlying surface 9, meaning for example that the prosthesis foot is shown in Fig. 2 to be adjusted to carry a shoe having a heel height that corresponds to the distance between the heel underside and the surface 9 minus the thickness of the sole at the pad portion 7 of the sole. The stud 28, the longitudinal axis of which coincides in said normal position with the longitudinal axis of the attaching means 29 of the adapter and the attaching means connectible with the attaching means 29 of the prosthesis lower leg not shown, is further so oriented that its extended longitudinal axis intersects the underside of the sole at its central portion, and this intersecting point is shown in Fig. 1 together with the sole projected on the underlying surface and designated by C. A line D extends through this point C which is

shown in Fig. 1 to coincide with the sectional line II-II and which intersects the line B at right angles and shows the "walking direction" of the prosthesis foot in relation to which the prosthesis foot is built in the intended way considering the carrier's individuality, at least with respect to inwardly and outwardly bent toes, and formed to suit usual shoes.

The joint connection stud 28 extends without clearance through a hole 30 in the core 1 and is threaded at its lower portion and provided with a nut 31 and a washer 32 between the nut and the core 1. The nut 31 is accessible from the sole of the foot prosthesis through a hole 33 made therein. There is a support cradle 34 attached on top of the core 1, the upper longitudinal edges of which are beveled obliquely downwards-outwards and through which the stud 28 extends, preferably without clearance. The support cradle can be integral with the core 1 and, thus, need not be a separate part. In the support cradle 34 there is arranged a bearing body 35 of an elastic material, for example rubber or a corresponding plastic material having a hardness of 60-100 Shore, preferably 90 Shore, said body having its seat in the support cradle 34, the seat surfaces, i.e. the surfaces of the guide body and the support cradle facing each other, not having to be circular, as shown on the drawings, but may have any other, mutually agreeing form. On the other hand, the longitudinal shaft of the bearing body should be arranged at right angles to the walking direction of the foot and its upper side should be arcuate and preferably semi-circular to coact with a preferably semi-circular cap 36 formed in a corresponding way and included as a part of the adapter 26 and to bear against and be supported by the bearing body 35.

The joint connection stud 28 also extends through

a hole 37 in the bearing body 35 and through a hole 38 in the cap 36, which latter hole is formed to be oblong in the walking direction and may have a greater width than the diameter of the guide pin. Thanks to this hole 38 oblong in the walking direction in the cap 36 a relative motion between the adapter 26 and the prosthesis foot around a shaft is made possible against the action of frictional forces appearing between bearing body 35 and cap 36, said shaft being parallel to the line B and lying in the center of curvature of the surfaces of the bearing body and the cap facing each other, i.e. the adapter can turn forwards and backwards in a vertical plane in the walking direction.

In order to further impede this movement the adapter 26 is provided on its front side and rear side with projecting and consolidated support flanges 39 and 40, respectively, which in the normal position shown in Fig. 2, also, bear against each their cushioning means 41 and 42, respectively, arranged on ths core 1 of the prosthesis foot, each in the form of elastic plastic or rubber cushions having a hardness of 40-70 Shore, preferably 50-60 Shore. As soon as the adapter 26 is turned the cushioning means 41, 42 concerned thus offers resistance by being compressed which increases with increased motion and thereafter contributes to returning the foot to the normal position shown in Fig. 2. In this way no abrupt stops are obtained but a successive braking of the movements, and in this connection the body weight and leg strength of the prosthesis carrier is of a great importance.

In order to eliminate said importance a compression spring 43 is arranged in the front cushioning means 41 in a replaceable way, the spring force of which is adapted to the weight of the prosthesis carrier - the heavier person, the stronger spring. The

spring 43 can be recessed in a hole 45 made in the core and provided with a protective sleeve 44, said spring being provided with a guide pin 46 at its ends bearing against the hole bottom and the support flange 39. Moreover, there is arranged an elastic braking layer 47 of rubber or a corresponding plastic material having a hardness of 70-100 Shore, preferably 90 Shore and which is kept in contact with and pressed against the cap 36 in the adapter 26 by a stiff pressure washer 48 through which the joint connection stud 28 passes without clearance like the braking layer 47 and which stud bears against the thrust washer 48 with a head 49. Thus, the whole articulate device 27 is kept together by means of the joint connection stud 28 and the flexibility and mobility of the articulate device is adjustable in this way all according to need and adaptable to the weight and leg strength of the prosthesis carrier by turning of the head 49 or nut 31 of the joint connection stud.

By this inventive arrangement a certain lateral movability is also obtained as the bearing body 35 and the braking layer 47 are of a resilient material. The elastic braking layer 47 contributes to a large extent to the unique function of the present prosthesis in respect of the possibility of walking also in descent and ascent without problems and without the leg even tending to give way. When walking in descent, as is well-known, the heel is first placed on the underlying surface simultaneously as the remaining part of the foot will not have any support from below, meaning that in the moment of being placed on the ground the prosthesis foot is exposed from below to an upwardly directed force dependent on the weight of the prosthesis carrier giving a transient torsional moment that will turn the prosthesis foot downwards against the underlying sur-

face and against the action of the rear cushioning means 42 which, however, offers the least resistance at the beginning and can therefore not counteract said torsional moment. However, this transient torsional moment is not absorbed according to the invention by the braking layer 47 bearing against the cap 36 of the adapter together with the bearing body 35 also bearing against the cap 36 in such an efficient way that the prosthesis carrier feels as if his prosthesis foot is a real foot, at least in respect of steadiness and adapted movability.

The braking layer 47 and the bearing body 35 function in the same way when walking in an ascent. The upwardly directed force dependent on the weight of the prosthesis carrier acts on the pad portion of the prosthesis foot and results in a transient torsional moment that will turn the prosthesis foot in an opposite direction and against the action of the front cushioning means 41. The moment arm will be longer than the moment arm obtained when putting down the heel, but this is finally compensated by the compression spring 43 with adapted weight and arranged in the front cushioning means 41. Moreover, the front cushioning means 41 can also be made bigger and be given a greater hardness than the rear cushioning means 42.

Another important function to get a foot prosthesis comfortable and correct during walking is the stamp of the step and this function which is directly depending on the stayed joint function with adapted weight of the present prosthesis is also built therein and, more specifically, in its toe portion 3 consisting of an elastic material, its length up to the core 1 being adapted to the weight and leg strength of the prosthesis carrier and the material in the toe portion 3 having a higher hardness than in the sole 4. More-

over, the toe portion 3 should have a vaulted or cupped upper side providing a greater resistance to bending of the toe portion than a flat toe portion. In other words, a resistance to bending is built into the toe portion 3 which is adapted to the weight and leg strength of the prosthesis carrier and which the braked joint 27 can manage so that the toe portion 3 when walking bends automatically like a real foot in "the toe joint" against the action of the built-in resistance that is taken up by the braked joint 27 without turning to any considerable extent. When the foot thereafter starts to be lifted from the underlying surface the toe portion 3 is given a possibility of springing back and to achieve in this way the stamp of the step so important for walking. The adaptation of the length of the toe portion up to the core 1 is illustrated by a dashed line 50 in Fig. 2 and it is unambiguously apparent from this that if the toe portion is shortened and the core is made longer in a corresponding way the bending resistance in the toe portion 3 increases in a corresponding way and an increased bending resistance in the toe portion is also required after use of a prosthesis for some time due to increased leg strength.

Built-in properties are included in the prosthesis foot of the present invention making the prosthesis foot unique of its kind and these properties are due to the facts that the present prosthesis foot

is plane and stable on the support,

follows the walking direction all the time which eliminates wear in knee- and hip-joints and prevents deformation of the prosthesis foot,

has an adjustable heel so that the prosthesis carrier can use shoes having a different heel height,

is vaulted in the arch of the foot to suit all

types of shoes,

has a fair height difference between heel and line B or tramp line, thanks to which the prosthesis carrier need not reheel his shoes too often

adapts itself automatically when walking in descent and ascent, respectively,

has a low weight, for example 550 g at the size 41,

gives the prosthesis carrier a possibility of choosing his shoes himself and has an adapted hardness in the sole and the heel which will enable the prosthesis carrier to avoid dorsal and fungal injury and, moreover, will give him a good balance when walking.

This invention is not limited to what has been described above and shown on the drawings but it can be amended, modified and supplemented in many different ways within the scope of the inventive idea defined in the appended claims.

CLAIMS

1. Device in a prosthesis where a prosthesis foot and a connecting lower leg are mutually combined by means of a joint (27) permitting relative motion between the prosthesis foot and the lower leg with increasing resistance from cushioning means (41, 42) arranged at least on both sides of the joint, c h a r a c t e r i z e d in that the joint (27) is braked by means of an adjustable force adapted at least to the weight of the prosthesis carrier also before contact with any one of said cushioning means (41, 42) located on both sides of the joint.

2. The device of claim 1, c h a r a c t e r i z e d in that the force braking the joint (27) is such that it locks the joint (27) against motion during walking when the toe portion (3) of the prosthesis foot preferably consisting of an elastic material is bent, said toe portion having a built-in bending resistance adapted to the weight and leg strength of the prosthesis carrier.

3. The device of claim 1 or 2, said prosthesis foot comprising a stiff core (1), preferably of wood, and a body of an elastic material supported by said core and forming the toe portion (3), sole (4) and heel (5) of the prosthesis foot, c h a r a c t e r i z e d in that the transverse axis of the joint is parallel to the pad portion (7) and tramp line (B) of the sole and that the joint (27) comprises a stiff joint connection stud (28) arranged in a hole of the core (1) and forming an angle of 90° to the support when the prosthesis foot is adjusted for correct walking and resting with its pad portion (7) and heel (5) against the underlying surface, said guide pin connecting a lower leg adapter (26) to the core (1) of the prosthesis foot via the joint (27), said stud (28)

being arranged in a vertical plane intersecting the line (B) at right angles and forming the walking plane or direction of the prosthesis foot.

4. The device of claim 3, c h a r a c t e r - i z e d in that the joint (27) comprises in addition to the joint connection stud (28) a bearing body (35), preferably of an elastic material, and a cap (36) formed in the adapter (26), having a shape corresponding to said bearing body, bearing against this and provided with an oblong hole (38) in the walking direction through which the joint connection stud (28) stayed rigidly in the core (1) extends, as well as a hole (37) located in said bearing body (35), said stud (28) holding the joint (27) together being adjustably connected to the core (1) for adjusting the flexibility and mobility of the joint in dependence on the weight and leg strength of the prosthesis carrier.

5. The device of claim 4, c h a r a c t e r - i z e d in that a braking layer (47), preferably of an elastic material, is arranged on the upper side of the cap (36) and coacts with this, said joint connection stud (28) passing said braking layer (47) and pressing it against the cap (36).

6. The device of claim 4 or 5, c h a r a c - t e r i z e d in that the bearing body is arranged in a support cradle (34) formed as a part of the core (1) or as a separate member connected with the core (1).

7. The device of any one of the preceding claims, c h a r a c t e r i z e d in that a compression spring (43) having a spring force adapted to the weight of the prosthesis carrier is arranged as a braking aid in the cushioning means (41) located in the walking direction in front of the joint (22).
